ANALYSES OF DISTRIBUTIONS OF SELECTED RAILWAY RATIOS AND THEIR RELATION TO THE RATE LEVEL PROBLEM

BY

ROGER BEHM SAYLOR

B. S., Lebanon Valley College, 1938

A. M., University of Illinois, 1940

AN ABSTRACT OF A THESIS

SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR THE DEGREE OF DOCTOR OF PHILOSOPHY IN ECONOMICS
IN THE GRADUATE SCHOOL OF THE
UNIVERSITY OF ILLINOIS, 1947

URBANA, ILLINOIS

1947

ANALYSES OF DISTRIBUTIONS OF SELECTED RAILWAY RATIOS AND THEIR RELATION TO THE RATE LEVEL PROBLEM

BY

ROGER BEHM SAYLOR

B. S., Lebanon Valley College, 1938

A. M., University of Illinois, 1940

AN ABSTRACT OF A THESIS

SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR THE DEGREE OF DOCTOR OF PHILOSOPHY IN ECONOMICS
IN THE GRADUATE SCHOOL OF THE
UNIVERSITY OF ILLINOIS, 1947

URBANA, ILLINOIS

1947

ACKNOWLEDGMENTS

Vital to the completion of this study have been the encouragement, suggestions, and constructive criticisms of my advisers, Professors William A. Neiswanger and D. P. Locklin. I sincerely appreciate their interest in this study.

I am also grateful for the many informal discussions I have had with Professor Floyd B. Haworth and Mr. Daniel C. Anderson concerning certain parts of this study.

For any mistakes that may have crept into this work I, alone, am responsible.

R. UNIV. BIBLIOTHEEK LEIDEN

ANALYSES OF DISTRIBUTIONS OF SELECTED RAILWAY RATIOS AND THEIR RELATION TO THE RATE LEVEL PROBLEM

A. *The Problem*

When the Interstate Commerce Commission is faced with the problem of evaluating the adequacy of any given railroad rate level it must give some attention to the rates of return being realized by the railroads. The rate of return usually used by the Commission for this purpose has been computed by adding together the net railway operating revenues of all Class I roads and relating this to the total investment for these roads.[1] These rates are, in effect, weighted averages in which the rate of return of each railroad is weighted by the investment figure for that road. Since the measures used are, in effect, averages they have all the limitations as well as advantages of averages.

Present indications are that the credit standard may be used in the future to judge the adequacy of returns to the railroads. The ratio of net income available to service capitalization to capitalization as represented by total stock and long-term debt is therefore a pertinent ratio which is used in this study. Also, the limitations of averages have been overcome by considering the distributions of observations along with the averages. In the past little, if any, attempt has been made to measure statistically the dispersions of railway earnings or financial ratios although it has long been recognized that there is a dispersion among the earnings of the railroads.[2]

[1]For example *General Commodity Rate Increases, 1937*, 223 I. C. C. 657, 666 (1937).

[2]D. P. Locklin, *Economics of Transportation*, (rev. ed.: Chicago: Richard D. Irwin, 1947) Chapt. XVII, "The Weak-and-Strong-Road Problem."

In this study an attempt is made to describe statistically the distributions of selected railway ratios of the railroads of the United States. A special effort is made to observe the effects of the business cycle on these distributions. Efforts are made to consider these distributions and their characteristics in conjunction with rate level problems. It is possible that the distributions of ratios of railroads with certain common characteristics may be considerably different from the distribution of ratios of railroads with other characteristics. The ratios are, therefore, studied with the railroads classified by several different methods. The average positions of the ratios of individual roads within the distributions are measured, as are the stabilities of the ratios of the roads within the distributions.

B. *Method of Approach*

The setting up of a quantitative measure to judge the performances of the railroads in order to judge the fairness of any existing rate level was done on the theory that the credit standard, as suggested by the Supreme Court in *Federal Power Commission* v. *Hope Natural Gas Co.*,[3] might be the basis for judging adequacies of rate levels in the future. The denominator of the ratio set up for this purpose was the sum, taken from the December 31st balance sheets of the railroads, of "Total stock" and "Total long-term debt." In this way the denominator represented the capitalization which had to be serviced at or near the market rate of interest in order for a railroad's credit standing to be satisfactory. The numerators of the ratios were designed to represent, as nearly as possible, the net income available to service stock and long-term debt. The income statements of the railroads for the years ending December 31st were used for this purpose. From "Income available for fixed charges" for each road were subtracted "Rent for leased roads and equipment" and "Interest on unfunded debt," unfunded debt being short-term debt.

[3]320 U. S. 591, 603 (1944).

The period selected for some parts of the study was 1923 through 1945, for others 1926 through 1945. No years before 1923 were used because the effects of Federal operation of the railroads during and just after World War I may still have been present to an important degree. It was desired for purposes of comparability to use an unbroken period of private operation of the railroads. 1945 was the last year for which data were available when this study was started.

The railroads used in this study were all the Class I operating companies for which complete data were available. In the later years of this period there were about six roads for which complete data were not available. The smallest number used in any one year was 124. The number decreased some with time because of consolidations and some taking over the operation of affiliates.

In addition to the net income to capitalization ratios just described the operating ratios of the railroads were examined. This was done on the theory that operating ratios, to some degree, measure the efficiency of operation of the roads and should logically have an important effect on the net income to capitalization ratios.

C. *Measures of General Distributions of Ratios*

The principal statistical measures used to describe any distribution are those of the mean or average, dispersion, skewness, and kurtosis. These four characteristics of the ratios were found by computing, respectively, the mean, standard deviation, $Beta_1$, and $Beta_2$ for each year. In addition the Pearsonian curve types for the distributions were determined to give clearer over-all pictures of the distributions.

These measures, when computed for the net income to capitalization ratios yielded the following results:

1.) The mean ratios for the period examined, 1923-1945, had a cyclical pattern which conformed closely to that

of general business activity, at least until near the end of the war period. This close conformity was expected because business activity determines, to a very large extent, the amount of traffic available for hauling by the railroads. Lack of complete conformity may be based partly, at least, on the fact that the railroads are not free to adjust their fares and charges as they wish since they are under Interstate Commerce Commission control to a large degree.

2.) The spread of ratios about the mean ratio was generally greater in years in which the means were high than in years in which means were low. However, there were wider dispersions among the ratios in the prosperity period of the 1920's than in the war prosperity period. These spreads are the results of such factors as differences in resources of territories served, populations in areas served, quantity and quality of competition, efficiency of management, and modesty of capitalization. Modesty of capitalization has had very important effects on the spreads in the various phases of the cycle. In poor years almost no railroads had very large net incomes available to service capitalization, so that practically all roads, including those with very light capitalizations, had ratios close to zero. In more prosperous years, though, the net incomes were greater for most roads with the result that those with very modest capitalizations often had extremely high ratios.

3.) The distributions of ratios in almost all years had positive skewness. That is, there were more extremely high ratios than extremely low ratios. The number and degree of extremity of very high ratios were greater in times of business prosperity than in depression periods. The number and magnitude of negative ratios were greatest in the depression years. The presence of more extremely high ratios than extremely low ratios seems to lie largely in the fact that there is no practical upper limit to the ratios but that a road with negative ratios for a number of consecutive years cannot continue separate operation without financial aid from some

source.

4.) The measures of kurtosis, the $Beta_2$ values, indicated that in all years there were very heavy concentrations of ratios close to the mean ratio, but there were also a few very extreme ratios in most years. The heavy degrees of concentration about the means can partially be attributed to the general attitude of the Commission in trying to aid the weaker roads, frequently at the expense of the stronger ones. The extreme ratios generally belong to roads with very modest capitalizations or very favorable traffic conditions, or both, since practically all of them are on the positive ends of the distributions.

The Pearsonian curve types which provided the best descriptions of the distributions for the various years were not randomly distributed through the time period. For the periods 1923-1929 and 1936-1945 curve types VI and I provided the best descriptions. These are both highly skewed types of curves. For 1930 through 1935, all depression years, type IV provided the best fit. Type IV is the type of skewed curve which is closest to being symmetrical. However, the criterion of stability for the Pearsonian curves indicated that the type IV curves would not give good descriptions of the ends of the distributions, while for type VI and I curves the criterion did not indicate this instability. The Pearsonian curve types provide descriptions of the sort of distributions we would be likely to get if the conditions existing in those years were to be repeated, substantially, in some future years.

Since efficiency of operation would logically be a factor in determining the ratios of net income to capitalization the operating ratios were examined. Correlations of the operating ratios and net income to capitalization ratios revealed that for the roads with over 2000 miles of track about 50 per cent of the variations in the net income to capitalization ratios were associated with variations in the operating ratios. There was reason to expect some correlation between the two ratios but not complete correlation since the bases

of the two ratios are not the same. Also some items of income and expense affect the net income to capitalization ratios but not the operating ratios.

The application of statistical measures to the operating ratios for the years 1926 through 1945 yielded the following results:

1.) The mean operating ratios followed a cyclical pattern which was roughly the same as that of general business activity. It was only rough because both the numerator, operating expenses, and the denominator, operating revenue, vary considerably in the different phases of the cycle. Expenses can be adjusted, to some extent, to changes in revenue.

2.) The spreads of the operating ratios were greater in depression years than in the years of greater business activity. This is attributable principally to a number of rather unfavorable ratios in depression times, and few in more prosperous years.

3.) The distributions of operating ratios had a high degree of symmetry in most years, there being about half of the ratios above the mean and half below. In 1932 the distribution included several highly unfavorable ratios and therefore had considerable positive skewness. In most other years the skewness was slight and neither consistently positive nor negative.

4.) The concentrations of ratios about the means, as indicated by the measures of kurtosis, were generally greater than for the normal curve of error, but not nearly as great as for the net income to capitalization ratios. Correspondingly, there were few very extreme operating ratios.

In almost all years the Pearsonian curves that gave the best fits to the distributions of operating ratios were type IV, indicating that all were quite close to being symmetrical distributions.

The differences in results of the statistical measures applied to the net income to capitalization ratios and the operating ratios can be attributed principally to the extremes among the former ratios. These were caused mainly by the low capitalizations of several roads.

D. *Testing of Classifications of Ratios*

In any given period of time it may be that a portion of the railroads with somewhat common characteristics are earning considerably more or less than the other roads. In such cases it might be possible to make adjustments for such classifications of roads by changing portions of the rate structure only. For this reason several classification methods were tested in this study, these being by geographical location, by size of road, and by type of freight hauled.

Two different, but related, tests were used to look for important methods of classifying the roads. The "J" test consisted of finding the percentage of total variation among the roads' ratios in any one year which was explained by the classification system being examined. The total variation of the ratios was found and also the sum of the variations about the class means. By relating the remaining variation to the total variation and subtracting it from one we found the variation explained by the classification system.

The other test, the "H" test, took into consideration the number of observations in the classes in addition to the differences of means and variations as used for the "J" test. In this case the classes were tested in pairs to find those between which there appeared to be sufficient differences to warrant contemplation of a rate level change for the roads in one classification. The pooled standard deviation of the two classes being tested was found. This was divided by the square root of the total observations in the two classes. The difference between the two class means was then related to this quotient.

The setting of critical values for "J" and "H" involves matters of policy that only a regulatory body could make. In this study the critical value of "J" was set at about 2.5 per cent and of "H" at about 1.75. These seemed to be workable values, but they might best be set at some other points.

In order to test the ratios by geographical classificiation the roads were classified by Eastern, Southern, and Western districts, as is generally done by the Interstate Commerce Commission. The tests were run a second time with the Pocahontas roads omitted from the Southern district. This was done because of the peculiar nature of most of those roads, they being extremely favorably located coal carriers.

The results of the tests of net income to capitalization ratios by geographical classification indicated that there were important differences among the classes in just a few of the years. These years occurred mostly in the 1924-1927 period and in the war years. In both periods the Southern roads had the highest mean ratios. The tests were re-run with the Pocahontas region roads and one or two other extremes omitted. These omissions resulted in serious doubt being cast on the importances of differences in 1926 and 1927.

Since the Southern roads have had the least favorable operating ratios in some years in which they had the most favorable net income to capitalization ratios it appears as though the Southern roads are generally less heavily capitalized than are the others.

The results of this part of the investigation cast some doubt on the usefulness of this geographical classification in an effort to equalize credit standings among the railroads. There have been only a few periods in which important differences existed, and in those periods the Southern roads had the highest net income to capitalization ratios even though their operating ratios indicated that they were not generally most efficient in their railroad operations.

In order to learn the effect of size of road on the ratios the roads were classified by size. The large roads were considered those which operated over 2000 miles of track, the middle-sized roads those which operated 500 to 2000 miles of track, and the small roads those which operated under 500 miles of track.

The tests for important differences among the mean net income to capitalization ratios of these classifications revealed that there were almost none in the years tested, 1926-1945. About the only noteworthy situation concerning the means was that the small roads had the poorest mean ratios in most of the early years of the study, but in the later years they had the best mean ratios. This is probably due to the fact that some of the weaker of the small roads have ceased independent operation while the stronger have maintained independent operation.

One fact that stood out regarding the ratios classified by size of road was that there was a consistent relationship among the variations within the classes. With one lone exception, the ratios of the large roads had the smallest spreads and the small roads' ratios the largest spreads.

The results of these tests of the ratios of the roads classified by size indicate that there would be little occasion to try to increase the rates charged by roads of one size compared to those charged by roads of other sizes. If such an attempt were made it might of necessity be by adjusting the divisions of joint rates to favor the classification of roads needing aid.

One possible suggestion arising from this study of ratios of the roads classified by size could be that the small roads be given only secondary consideration in the establishment of rate levels. Primary consideration should then be given just to the large and middle-sized roads since the performances of the small roads have been far more erratic than the others.

In setting up the classes to test the roads' ratios by type of freight hauled only the large and middle-sized roads were used. In one class were placed the roads whose tonnage carried consisted of at least 80 per cent products of mines, and manufactures and miscellaneous. These roads were those tied in very closely with heavy industry. In a second class were placed roads whose tonnage consisted of at least 20 per cent products of agriculture, and animals and animal products. The third class included those with more diversified traffic, that is, with tonnage consisting of less than 80 per cent products of mines and manufactures and less than 20 per cent products of agriculture.

The roads carrying principally products of mines and manufactures had the highest mean ratios for all years 1926 through 1941 with the exception of 1932. The differences among mean ratios were important in most of those years according to the results of the "J" tests. After 1941 the differences were insignificant.

Efforts to equalize the net income to capitalization ratios in the years in which those of the roads basically dependent upon heavy industry were appreciably higher than the others would generally have necessarily been by trying to raise, particularly, rates on products of agriculture. Considering economic conditions in agricultural areas in those years, especially the 1930's, this would have brought great protests from those regions. Raising of rates on any other type of freight would have tended to provide greatest help to roads which needed it least.

E. *Stabilities of Net Income to Capitalization Ratios of Individual Roads*

In order to gain a clearer picture of changes in the internal structure of the distributions of net income to capitalization ratios measures were computed of the average positions of the ratios of individual roads in relation to the mean ratios of the distributions. Also, measures were

computed for the stabilities of the individual roads' ratios within distributions by computing the standard deviations of the positions of the ratios of the road about the mean position for that road's ratios.

The mean positions of the large roads' ratios were generally more concentrated than were those of the smaller roads. In fact, the only large roads with mean positions not within a few points of the general average of all roads were the Pocahontas roads, the Norfolk & Western and the Chesapeake & Ohio. The middle-sized and small roads' mean positions were much more widely scattered. Several, such as the Columbus & Greenville and the Cincinnati, New Orleans & Texas Pacific had very high mean positions, partly, at least, because of their modest capitalizations.

The larger roads' ratios also showed greater stability within the distributions from year to year than did those of the other roads. Some of the middle-sized and small roads, particularly, had ratios which jumped around violently within the general distributions as the different phases of the business cycle occurred. These were generally roads which depended completely on the steel industry for their traffic or which had rather low capitalizations.

The results of the measures of stability of net income to capitalization ratios are in close agreement with the results of the study of the ratios classified by size of road. In both cases the measures of dispersion yielded relatively low values for the large roads and relatively high values for the small roads.

F. *In Conclusion*

Through this study the assumption has been made that the principal method of attempting to adjust earnings of all roads or any portion of them would be by adjusting the rates they charged. In an attempt to evaluate adequacy of rates the first step would logically be to compare the mean net

income to capitalization ratio, if those ratios may be used as our measures of performance, with the rate of return that is judged ideal. This ideal rate may be based on current yields of selected types of securities or may be some arbitrarily determined rate.

Because the majority of roads ordinarily have earnings below the general average a comparison of the mean ratios with the ideal rate of earnings, however set, presents an over-optimistic picture of the performances of most roads. By use of plotted cumulative distributions of the ratios a clear picture can be gained of the proportion of the roads whose ratios are larger or smaller than the ideal ratio. At the same time some idea can be gained of what proportion of the roads have ratios within any given range of the ideal ratio. In this way it is possible to judge the standings of any given proportion of the roads in relation to the ideal ratio. If it is found that too few roads have ratios close to the ideal ratio a general rate increase would apparently be in order. If too large a proportion of the roads have ratios exceeding the ideal ratio a general rate decrease would appaently be called for.

There would always be some roads with ratios undesirably far from the ideal ratio. Most of the very extreme ratios are on the upper ends of the distributions and present no particular problem. There are some on the lower ends of the distributions which seemingly cannot be raised sufficiently by any method. No general rate level adjustment would remove these ratios from the ends of the distributions.

The solution of the problem of just how great an adjustment in the general rate level would be necessary to get any desired portion of the roads' ratios above or below the ideal ratio is complicated by several factors. In the first place a general rate level change, even with no change in volume of traffic, would not affect the ratios of all roads equally. This is because operating revenues represent different percentages of capitalization for the different roads.

If volume of traffic and expenses remained constant, a change of 1 per cent in the net income to capitalization ratios would require as much as a 6 per cent change in rates for some roads and less than 1 per cent for others. In the second place the demand for the services of the railroads may be such that a rate level change would cause a change in volume of traffic hauled.

The unequal effects of a general rate level change would probably be most noticeable on the very high ratios, but they would also reach the ratios near the mean ratio. These ratios would also be affected unequally by any given rate level change because of differing relationships of operating revenues to capitalization. Therefore the probable effect of any proposed rate change on the distribution of ratios could only be determined after special investigation of some of these other matters.

The results of the studies of classification systems of the roads have yielded some directly useful information, but they have also indicated emphatically that there are other factors responsible for large portions of the variations among the ratios. Some of these factors, moreover, are probably of the type that they could hardly be used as bases for rate adjustments.

The most important missing links appear to be measures of freight density, or rate of plant utilization, and conservativeness of capitalization. A measure of freight density expressed, if possible, in physical units might be very useful. A perfunctory examination of this problem revealed that it would be a major project in itself to formulate such a measure with a good weighting system since density of freight has little relationship to the rate charged.

A second desirable measure would have been of the conservativeness of capitalization of the various roads. The study of stabilities of the net income to capitalization ratios of the individual roads superficially pointed out some of the

roads with very light and very heavy capitalizations, but it could not be expected to do a thorough job of this.

Finally, it may be said that this study has yielded descriptions of the distributions of the railroads' performances as measured by the net income to capitalization ratios. These descriptions cannot in themselves provide the answers to rate level problems or any other problems. They do, though, point out some of the peculiarities of the problems and some of the changes in peculiarities related to the business cycle.

The general methods used in testing for important differences among classes were by relating them to the dispersions of the ratios. They have possible uses as objective criteria for deciding when rate changes should be considered for different classifications of the roads.

The applications of these methods to net income to capitalization ratios for past years produced some interesting descriptive results. However, there is little indication that use of them throughout the period studied would have resulted in all or even a fair portion of the rate level problems being solved. It could conceivably, though, have resulted in a few worthwhile rate adjustments.

The study of the operating ratios showed that there was a definite relationship between the operating ratios and the net income to capitalization ratios. Also, it indicated that other factors than operating efficiencies, at least as measured by operating ratios, had vital effects on roads' performances although these factors were not consistent in their effects on the various classifications of roads.

VITA

Roger Behm Saylor was born in Reading, Pennsylvania, on May 23, 1917. He attended the public schools of East Orange, New Jersey, graduating from East Orange High School in 1934. His undergraduate work was done at Lebanon Valley College, Annville, Pennsylvania. He received the Bachelor of Science degree in mathematics from there in 1938. The following year he worked for L. Bamberger & Co. of Newark, New Jersey, a large department store. In September of 1939 he enrolled in the University of Illinois and qualified for the Master of Arts degree in economics in June of 1940. He continued his graduate work at the University of Illinois through the summer of 1941. During World War II he was first a civilian employee of the United States Army and then a member of the United States Coast Guard. After his release from active duty in the Coast Guard in December of 1945 he returned to the University of Illinois to resume his graduate work. From March of 1946 to June of 1947 he held a part-time assistantship in economics.